

Real-Time Six Sigma

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KEYWORDS

DMAIC, Six Sigma, Performance Monitor, Process Monitor, Loop Health, Optimization, PID Loop Tuning, Performance History, Performance Dashboard

ABSTRACT

Six Sigma is a five step procedure for systematically optimizing a process. A performance monitor provides continual Six Sigma analysis of a process.

The five steps in Six Sigma are:

- 1) Define the process to optimize. The software divides the entire plant into individual unit operations. Each unit operation is defined as a process to optimize.
- 2) Measure current performance to get a baseline of where you are now. In the software, you select a historical window of time when the plant was running well. With the window selected, the software automatically sets the baseline of performance to either the average, sigma value or min/max value of the key metrics selected for this plant.
- 3) Analyze the process to pinpoint problems. A Biggest Payback Loop list provides a prioritized list of loops to work on that will yield the largest economic return.
- 4) Improve the process. Analysis tools integrated within the performance monitor allow improvements to be made directly to the control system. The software includes a myriad of tools for this step depending on the improvement required. For example, applying the appropriate filter to the control loop will extend the life of the valve. Another example would be PID tuning that is robust and makes sense for process being controlled.
- 5) Control. Setup controls to prevent future problems. The software should include loop, unit operation and plant performance histories to track performance over time.

These steps of Define, Measure, Analyze, Improve and Control are often abbreviated with the shorthand notation DMAIC. Implementation of these steps are discussed in detail in this paper.

DEFINE THE PROCESS TO OPTIMIZE

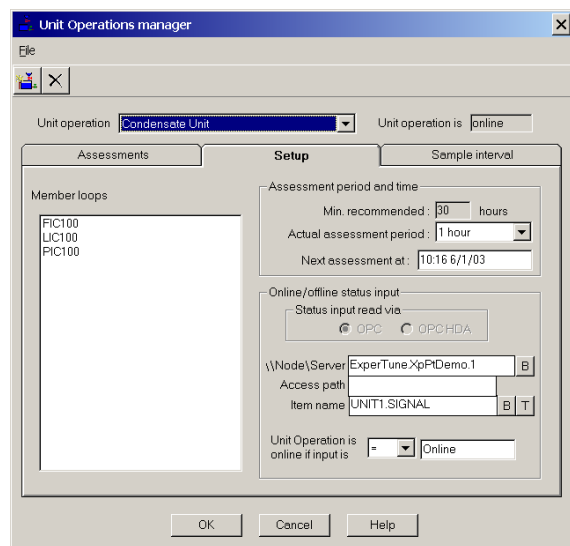


FIG. 1 - WINDOW SHOWING SELECTION OF UNIT OPERATION

The performance monitor should divide the plant into individual unit operations. These operations define each specific location to analyze.

MEASURE CURRENT PERFORMANCE

The baselines indicate a reference value to compare against in the future. The software should allow selection of a baseline over a time period. The software should allow the baselines to be fixed or to be an average value.

BASELINE TREND WINDOW

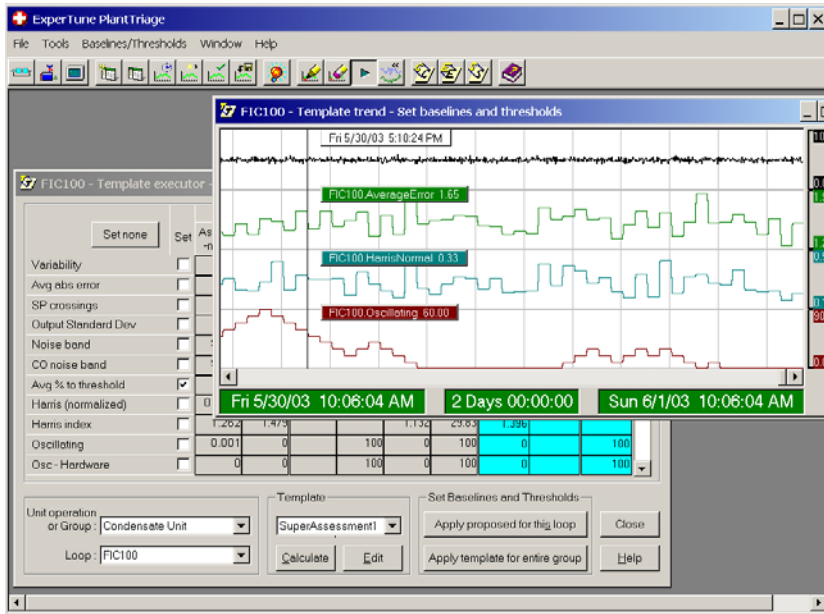


FIG 2 - GRAPHICAL SELECTION OF BASELINE TIME

The software should allow the user to select a window of time to use as the baseline time. Flexible zooming and panning via graphical interface or manual entry should both be available to allow the user to easily select the time he would like to use for the baseline. The window should display the PV (process variable) for a loop and also user selectable performance assessments for that loop. These should be all trended together. Different loops should be easily selectable via a drop down combo box. Selecting a different loop, immediately switches the trend display to that loop's PV and assessments for the time window the user has selected. With this window selected the user applies a template to set the baselines and thresholds for all the loops in a unit operation or group of loops.

LOOP HEALTH

To make use of the assessments, the software should incorporate concepts of baselines, thresholds, templates and triage or the priority of this loop. The combination of assessments, baselines, thresholds, and economic significance for a loop should determine how well that loop is doing. This determines the health of a control loop.

Thresholds represent limits or boundaries between which the assessments would remain if the plant is running well. All thresholds should be bi-directional. For example, a threshold may be set above the baseline and/or below the baseline.

Some assessments on specific loops may not be important to the concept of loop health for a particular business. The software should allow for some assessments to be ignored for some loops or some categories of loops.

KEY ASSESSMENTS

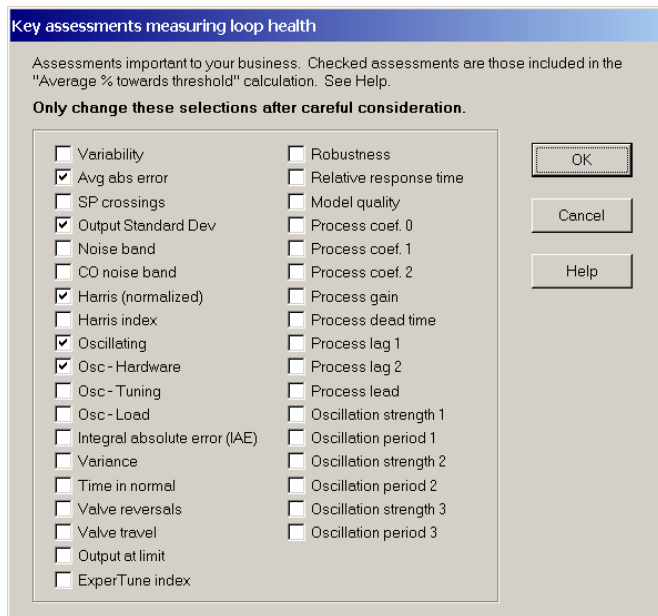


FIG 3 - KEY ASSESSMENTS ARE ONE PART OF THE DEFINITION OF LOOP HEALTH

Baseline and thresholds should be settable on every assessment, but only several assessments should be chosen as those key assessments measuring loop health. The assessments that make up loop health should be easily selectable by the user.

TEMPLATES

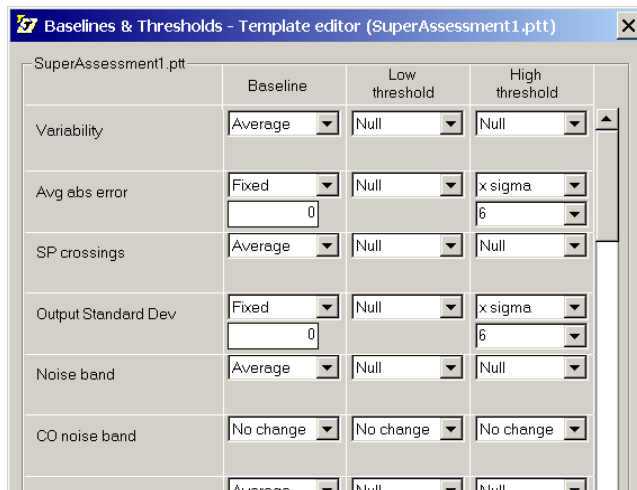


FIG 4 – USING TEMPLATES THE SOFTWARE SHOULD ALLOW THE DEFINITION OF LOOP HEALTH TO BE SET UP FOR THOUSANDS OF LOOPS IN UNDER 1 HOUR

There could be near 40 assessments performed on every control loop. Since baseline and threshold values could be defined for each assessment, potentially 80 settings could be made for every loop. If a plant has 1000 loops, this would be 80,000 settings a user needs to make before real-time six sigma becomes a reality. There needs to be a better way to quickly set these baselines and thresholds. The concept of templates is the answer.

Templates should be available in the software that allow the user to quickly set the baselines and thresholds for a loop, group of loops or an entire unit operation. Templates should allow for customization on how these are set for specific plants. For example, all flow loops could be quickly set based on a flow loop template. Templates should allow for all baselines and thresholds to be set on all assessments in a very efficient manner. Templates should allow processing of the data to set baselines and thresholds over the Baseline Trend Window discussed above.

Templates should allow for baselines to be a fixed value, average value, not set, or not changed. Templates should allow for thresholds to be fixed value, min or max value, some sigma value, not set, or not changed. Thresholds set on the sigma value should allow for a sigma multiplier of any value the user desires. This allows the user to set the threshold at 6 sigma, for example.

ECONOMIC SIGNIFIGANCE

Every loop should be assigned an economic significance and the software should allow for this assignment and incorporate this value in its computation of overall loop health.

ANALYZE THE PROCESS TO PINPOINT PROBLEMS

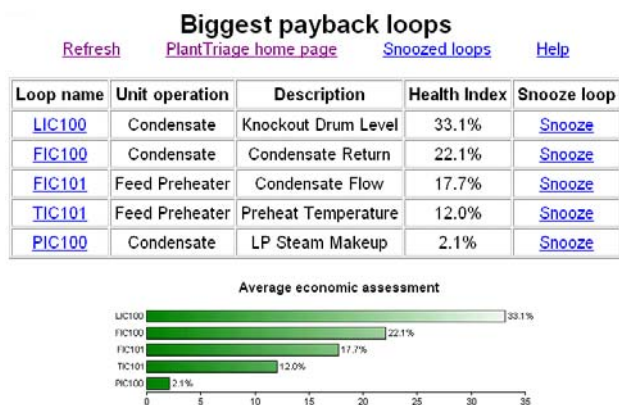


FIG 5 - THIS LIST PINPOINTS THE AREAS THAT BY REPAIRING WILL HAVE THE BIGGEST POSITIVE IMPACT ON THE BUSINESS

The software should automatically assess the plant, and based on the settings of the key assessments, baselines and thresholds discussed above, determine the overall health of individual loops, units and the plant. A list of loops in priority order of those needing the most attention should be given. This list shows the worst performing loop at the top of the list. The next worst performer next and so on. Thus,

the loop at the top of the list is the one that impacts the economic viability of the plant the most. This list should pinpoint the problems in specific units, and plants.

The list should be updateable in real-time so that after every assessment on any unit the list will show the very latest priority of loops.

IMPROVE THE PROCESS

With problems pinpointed via the priority listing, the software should include tools to allow repair and improvements to the process. These tools should be an integral part of the software making access easy so that they are actually used. Problems pinpointed and tools provided to address these should include:

VALVE HARDWARE PROBLEMS. An easy-to-use stiction analysis tool should be provided that quantifies the amount of stiction in the loop. An easy-to-use hysteresis tool should also be provided that quantifies the amount of hysteresis in the loop. Stiction is usually more damaging to plants than hysteresis but both can cause cycling and reduce performance. 1

LOOP INTERACTIONS. A tool for looking at the dominant periods of cycling in all the plant loops will group those causing a problematic cycle helping pinpoint that loop causing the cycle. Another tool for measuring the relative response time of each loop allows for decoupling - adjust tuning to move the relative response time of interacting loops apart by a factor of 3.

LINEARITY. A tool not only for measuring the linearity of the loop, but also including a characterization designer for linearizing the loop. Should provide for both overall loop non-linearities, including process non-linearities and pH or pION type loops.

FILTERING AND VALVE WEAR. Should provide a tool that automatically determines the best PV filter to use in the process. Should design, first order, second order, averaging, and second order butterworth filters. Should also allow for simulation of the effect of the filters in the control loop. Should also include valve wear indicators that demonstrate the effectiveness of the filter or differing tuning constants in simulation.

PID TUNING. Should provide for at least 2 categories of PID Tuning: tuning for setpoint response and tuning for load rejection. Both types should be settable with one tuning parameter: a safety factor for load tuning, and a settling time for setpoint tuning. The tuning parameter adjusts the speed of response traded off with the robustness of the loop.

ROBUSTNESS ANALYSIS. The software should include some form of robustness analysis. There is always a trade-off of tuning and robustness. There should be some graph preferably showing how changing process gain and dead time will affect the stability of the loop with a particular set of tuning constants.

SIMULATION. To see how effective PID tuning, robustness analysis and filtering (valve wear) analysis are, there should be integrated simulation capability in the tool.

CONTROL

The software should include loop, unit operation and plant performance histories to track performance over time. These histories should include drill-down functionality to allow seeing in more detail specific issues.

This in effect is a real-time dash-board view into the performance and health of the plant. This should answer the questions "How is my plant performing now?". "How is the plant performing compared to yesterday, last week, or last month?"

CONCLUSION

A process monitoring and optimization package should continually monitor and assess the plant for problem loops. It should identify those loops and provide seamless integrated tools for optimizing them. This allows for six sigma techniques to be utilized in real time. The benefits to the plant are an operation is a methodology and approach that is in sync with the needs of the business.

REFERENCES

"Stiction: The Hidden Menace", *Control Magazine*, November 2000 Michel Ruel